Q 64: Nano-Optics III

Time: Friday 11:00–12:30 Location: f342

Q 64.1 Fri 11:00 f342

Enhancing the spontaneous emission rate of a single emitter by a gold nanocone antenna — •Korenobu Matsuzaki[1], Hsuan-Wei Liu[1], Björn Hoffmann[1], Silke Christiansen[1,2], Anke Dutschke[1,3], Stephan Götzinger[4,1], and Vahid Sandoghdar[1,4] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Helmholtz Centre for Materials and Energy, Berlin, Germany — [3]Carl Zeiss, Oberkochen, Germany — [4]Friedrich Alexander University of Erlangen-Nürnberg, Erlangen, Germany

In a recent theoretical work, we have suggested that a gold nanocone can be an ideal plasmonic antenna, which allows one to modify the radiative decay rate of a single emitter by several thousand times while keeping its quantum efficiency high [1]. Here, we report on the first experimental realisation of this concept. The gold nanocones were fabricated by focussed ion beam milling on a glass substrate [2]. As an emitter, we used a colloidal quantum dot, which we attached to the glass tip of a near-field microscope. This configuration allowed us to position the quantum dot with nanometer precision with respect to the nanocone. We will report a reduction of the radiative lifetime by the order of one hundred times. Furthermore, we present a method to extract the radiative decay rate enhancement factor and the antenna efficiency from the experimental data by taking the photophysics of quantum dots into account. [1] Chen, Agio, and Sandoghdar, *Phys. Rev. Lett.* **108**, 233001 (2012). [2] Hoffmann, Vassant, Chen, Götzinger, Sandoghdar, and Christiansen, *Nanotechnology* **26**, 404001 (2015).

Q 64.2 Fri 11:15 f342

Few-cycle sub-10 femtosecond electron point source driven by nanofocused surface plasmon polaritons — •Melanie Müller[1], Vasily Kravtsov[2], Markus Raschke[2], and Ralph Ernstorfer[1] — [1]Fritz-Haber-Institut der MPG, Berlin, Germany — [2]University of Colorado, Boulder, Colorado 80309, USA

We report the nonlocal excitation of sub-10 femtosecond electron pulses triggered by nanofocused surface plasmon polaritons (SPPs) from the apex of a gold nanotip. Few-cycle SPPs are launched 20 μm away from the apex by broadband grating coupling of 5 fs laser pulses at 800 nm. Nanolocalized photoemission from the apex is verified by the specific focusing conditions of the electron beam inside an electrostatic lens. We measure a pulse duration of 7-8 fs of the plasmonic near field, triggering multiphoton photoemission within a time window of 5 fs. We employ this conceptually new ultrafast electron source for plasmon-triggered femtosecond point-projection microscopy (fsPPM) at a tip-sample distance of 3 μm with a geometric magnification >30,000 and image the nanoscale field distribution along the surface of a doped semiconductor nanowire. The remote excitation scheme allows for a significant reduction of the tip-sample distance compared to conventional far-field illumination of the apex, promising few nanometer spatial and few femtosecond temporal resolution in fsPPM as well as the implementation of time-resolved low-energy electron holography.

Q 64.3 Fri 11:30 f342

Above threshold ionization of Rydberg electrons localized to a gold nanotip — •Jörg Robin[1], Jan Vogelsang[1], Benedek J. Nagy[2], Petra Gross[1], and Christoph Lienau[1] — [1]Carl von Ossietzky Universität, 26129 Oldenburg — [2]Wigner Research Centre for Physics, H-1121 Budapest

Metallic nanotips are model systems to study nanometre and femtosecond electron dynamics and provide the possibility for ultrafast electron microscopy. Evidence of strong-field phenomena has been observed by one-colour photoemission of electrons from metallic nanotips [1-3], while two-colour photoemission has established the existence of surface states on metallic films [4]. Here, we report femtosecond two-colour photoemission of electrons from a gold nanotip. We observe long-lived wave packets of Rydberg electrons bound to their own image potential. These intermediate bound states facilitate above-threshold ionization similar to atomic systems and give access to a cold, ultrafast, nanolocalized electron source. [1] Krüger, M. et al. Nature 475, 78 (2011) [2] Herink, G. et al. Nature 483, 190 (2012) [3] Piglosiewicz, B. et al. Nat. Photon. 9, 37 (2014) [4] Höfer, U. et al. Science 277, 1480 (1997)

Q 64.4 Fri 11:45 f342

Quantum coherent Ramsey-type interactions of free electrons with spatially separated near-fields — •Katharina E. Echternkamp, Armin Feist, Sascha Schäfer, and Claus Ropers — 4th Physical Institute, University of Göttingen, Göttingen, Germany

A few years ago, inelastic interactions of free electrons with optical near-fields, i.e., the absorption and emission of multiple photons, were observed for the first time [1]. Recently, we experimentally demonstrated the quantum coherent nature of this interaction by measuring multilevel Rabi oscillations in the sideband populations of the electron energy spectra [2].

Here, we employ an ultrafast transmission electron microscope (UTEM) to realize a novel type of electron-light interferometer, in which free electron momentum superposition states are manipulated in a quantum coherent manner by two spatially separated optical near-fields. In the experiments, the electron beam passes a specially designed gold nanostructure, which enables precise amplitude and phase control of the two subsequent interactions. In some analogy to the Ramsey method of separated oscillatory fields [3], the relative phase between these interactions governs the total transition amplitude.

[1] B. Barwick *et al.*, Nature, **462**,902 (2009).
[2] A. Feist *et al.*, Nature, **521**,200-203 (2015).
[3] N. F. Ramsey, Rev. Mod. Phys. **62** (3), 541-552 (1990).

Q 64.5 Fri 12:00 f342

On the existence of TE resonances in graphene-dielectric structures — •Julia F. M. Werra[1], Francesco Intravaia[2], and Kurt Busch[1,2] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik & Photonik, 12489Berlin, Germany — [2]Max Born Institute, 12489 Berlin, Germany

In this talk, we discuss the existence and the properties of TE resonances in graphene-dielectric structures. In our description we assume that the contact with the dielectric does alter graphene's properties by inducing a bandgap in its electric bandstructure [1]. In contrast to previous results [2], we show that in this case the TE-plasmon resonance do not cease to exist.

Additionally, we show that, when graphene is in contact with a dielectric slab with finite thickness, it introduces a frequency cutoff for the slab's waveguide modes. This is a pure quantomechanical effect closely related to the pair-creation threshold in graphene [3].

These results do not only offer new ways of designing waveguides but they also provide a basis to understand the behavior and lifetime of, e.g. emitters, in the proximity of such graphene-dielectric structures.

[1] J. Jung, A. M. DaSilva, A. H. MacDonald, and S. Adam, Nat. Commun. **6,** 6308 (2015).
[2] O. Kotov, M. Kol'chenko, and Y. E. Lozovik, Opt. Expr. **21,** 13533 (2013).
[3] J. F. M. Werra, F. Intravaia, and K. Busch, arXiv:1511.00408 (2015).

Q 64.6 Fri 12:15 f342

Hyperbolic plasmons and Dyakonov waves in the topological insulator Bi2Se3 unravelled by swift electrons — •Nahid Talebi[1], Cigdem Özsoy Keskinbora[1], Hadj Mohamed Benia[1], Christoph T. Koch[2], and Peter A. van Aken[1] — [1]Max Planck Institute for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany — [2]Institut für Experimentelle Physik Universität Ulm Albert-Einstein-Allee 11, D-89081 Ulm

Materials crystallizing in tetradymite structure are fascinating, since at their bandgap just near to the Fermi level they sustain time-reversal-invariant topological effects. Another characteristic of tetradymites is caused by the huge uniaxial electric anisotropic behaviour of the material. Due to the interplay between the metallic and dielectric response, Bi2Se3 can be a proper case for studying the plasmonic excitations in hyperbolic materials with different bulk dispersion characteristics.

Here, utilizing electron energy-loss spectroscopy, we experimentally investigate plasmonic modes of Bi2Se3 nanostructures. Very interesting observations are the high intensities for the EELS signal almost all energies ranging from 0.8 eV up to 4 eV, while at higher energies the contribution of surface plasmon modes is more evident. Interestingly, even at the energy loss of E=0.8 eV in which the material is totally dielectric, the excitation of an edge mode is apparent, and can be explained by the excitation of Dyakonov waves. We furthermore investigate the surface waves and edge plasmon dispersions, both analytically and numerically, in order to obtain an improved understanding of our experimental observations.